A thick industrial design studio curriculum

INTRODUCTION

Izmir University of Economics is located on the Izmir bay on the Aegean coast of Turkey. Nearly six thousand students attend this English speaking private university which was established in 2001. The Faculty of Art and Design consists of 5 departments including the Department of Industrial Design, currently in it's fourth year. The department offers two specialisation areas that begin in the third year of studies: Product Design and Design Management. Design studio courses of the Department of Industrial Design are 5 credit courses that, for industrial design specialisation students, take place every semester throughout the 4-year undergraduate degree.

The first year Art and Design Studio I is a joint programme with fashion, architecture, interior architecture and communication design students that “aims to introduce the topic of design and its associated issues and problems.” The courses deal with representation and abstraction in design by means of problem exercises that evolve from 2D to 3D. In Art and Design Studio II in the second semester, with fashion students no longer participating, the course continues the same themes in a series of exercises determined and supervised by instructors from each department. Second year industrial design students attend the Product Design Studio I and II courses. For all students this is their first introduction to the 'designing' tools and methods of the industrial design discipline (henceforth ID). For design management specialisation students, these courses are two of few opportunities to do conventional ID projects. The 'Product Design Studio I' described here was taken by 45 students, supervised by three instructors. Product Design Studio I is a 5 credit course takes place in two 4-hour sessions, totalling 8 hours per week in a fourteen-week fall semester course. Product Design Studio II continues the same formula, applied in more detail and with more complexity, in the spring semester. Third and fourth year students who choose the Product Design specialisation are expected to focus on the practice of designing, covering design issues such as design engineering, advanced product development, service design, user-centred design, ecological design, and the latest technologies in executing industrial designs. Those who choose Design Management specialisation are intended to explore the economical and business related issues of industrial design by acquiring expertise and experience in both worlds of business and design practice in an industrial contexts.

INDUSTRIAL DESIGN PROFESSIONAL COMPETENCIES

The industrial designer is responsible for “creating and developing concepts and specifications that optimise the function, value and appearance of products and systems for the mutual benefit of both user and manufacturer” (IDSA, 2008). What essential competencies should be fostered in educating this person?

The famed car stylist is a good example of this kind of designer. They work in multi-disciplinary teams to define the interior and exterior forms, materials, textures and colours applied in the shaping of an automobile. Designers may be found employed in the R&D department of large manufacturing companies, or in specialised design consultancies, or as freelance designers. The ID profession's role emerged most essentially in automobile

manufacturing where they strived to lure and captivate consumers with annual model changes that, often, were mainly cosmetic. Consequently, the IDer's job was to create imaginative design concepts and render them in evocative and convincing art works or models. In Bayley's (1983) account, in the Art and Colour Section (later the Styling Department) of General Motors, famously headed by designer Harvey Earl, a new car body line would be initiated by a policy decision by senior management. Instructions, including certain fixed dimensional coordinates, would be given to the design studios (for each brand of GM car); the studios would produce design concepts that were selected for development in a process that began with sketches and ended in the form of accurate full-size drawings and models intended to communicated the concepts to management and other departments (Bayley 1983.) From Bayley's account it is apparent that the sought-after skills of IDers were:

- their imagination and sensibility in developing 'design concepts' that anticipated (or shaped) the needs and desires of consumers; and
- their talent or skill in 'communication,' making renderings, models, technical drawings and specifications to effectively communicate design concepts to other members of the product development team.

For the most part, instructional text books for IDers reflect four main preoccupations of the discipline: 'Process'—those that discuss design methods and processes, typically Tjalve (1979) and Cross (2000), or texts from other disciplines that inform ID such as ergonomics Cacha (1999) and Tilley (2002). 'Design concept'—books illustrated with examples of completed ID products in the form of annuals or monographs, IDSA (1997) and Fiell (2005) are examples. 'Communication'—those that teach skills such as drawing, rendering and model making, Powel (1990) and Shimizu et al (2000) are examples. 'Context'—texts that deal with ID history and theory of such as Forty (1986) and Margolin (1989).

Questions about the proper role of industrial designers are the subject of debate within the ID profession. In a recent study, Lewis and Bonollo (2002) described “the skills and personal characteristics of industrial designers so valued by clients and fellow professionals.” According to the authors, clients tended to evaluate the performance of their student designers in general terms:

1. Design process skills (broken down into the stages below)
2. Designed product outcomes
3. Social competence
4. Project management skills
5. Professionalism and career skills
6. General comments.

In a similar vein, Yang, You and Chen (2005) analysed the stipulated competencies and qualifications in industrial design jobs being advertised in Taiwan. Their twenty competencies, in descending order, were:

1. 3D graphic software ability
2. Basic communication ability in English
3. Fluency in English

4. 2D graphic software ability
5. Creativity and imagination
6. Can communicate, coordinate, organize
7. Active, aggressive, optimistic
8. Knowledge of molding tool or plastics injection
9. Aesthetic discipline
10. Can travel to China or abroad
11. Sketching and ideation
12. Interested in and devoted to design
13. Team spirit
14. Enthusiastic with sense of responsibility
15. Willing to learn and be diligent
16. International views
17. Popular messages and trends
18. High EQ with sharp observation
19. New product planning and marketing
20. (Clay) modeling

Educators should consider that graduates will most likely someday attain decision making or management positions. Professional knowledge and skills will need to be generalisable and robust enough to cope within a world of change. Equipping undergraduates for their future professionals for the world Friedman (1997) refers to a dichotomy between two philosophies of design education, the one “treats design as the skill of making an object or an artifact” rooted in a tradition of craft or vocational education; the second philosophy “treats design as a knowledge-intensive process that involves selecting goals, then developing and executing strategies to meet those goals.” His exhortation for designers to be equipped with the “intellectual tools of the knowledge economy: analytical, logical and rhetorical tools; problem solving tools; the tools of science” amounts to a call for a rigourous analysis and application of method in the design process. Yang, You and Chen's (2005) study suggests that industry is beginning to favour the second philosophy: “Perception and solution to problems, creative thinking, curiosity and motivation... more important than traditional design professional skills”. Buchanan (2000) argued about the need for designers with “adequate special knowledge.. also the wide perspective that is needed in the complex environment of the future.”

Graduating IDers hope that their new-found abilities will bode them well in their career. In time, they would expect to collaborate with, and lead team of specialists, where the focus shifts from what we call 'concept design'—concerned with imaginative design and detailing of products, working to pre-defined or specified product design briefs; to 'product design'—concerned with conceiving the entirety of a new product offering, where the design briefs themselves are being defined. (Note: Use of the terms 'concept design' and 'product design' to make this distinction is our own idiosyncrasy.)

COMMENTARY ABOUT COMPETENCIES

Our students may be described as 'novices', stage 1 of the skill acquisition model in the well-known conception by Dreyfus and Dreyfus (2005). Beginners are learning to recognise facts and features of the skill, they seek basic rules to follow, without understanding the context or overall situation. They might also be at stage 2–'advanced beginners', who will improve their performance through practical experience in concrete situations. The Dreyfus model continues with stage 3–'competent,' stage 4–'proficient,' and, finally, stage 5–'expert', who “not only sees what needs to be achieved; thanks to a vast repertoire of situational discriminations, he or she also sees immediately how to achieve the goal.” For our purposes it is sufficient to acknowledge the chasm between novice/beginner, on the one hand, and proficient/expert, on the other. Benjamin Bloom's equally well-known taxonomy of educational objectives describes skills in the 'cognitive domain' in a hierarchical progression; 'knowledge', 'comprehension', 'application', 'analysis', 'synthesis', 'evaluation' (Wikipedia, 2008). The novice designer undertaking a design project for the first time acts and makes decisions that entail knowledge and comprehension, and analysis, in a studio environment whose tradition is one of learning through application.

It's necessary to focus on essential abilities when teaching novices. To state the obvious: Design students want to learn how to design and teaching them is purportedly the central purpose of design studio courses, where gaining understanding and experience in the tasks of designing is a priority. To learn how to design is to develop a reflective understanding of the design process. Problem solving is “the core intellectual activity of a profession, represented in the case of industrial design by design process skills" (Lewis and Bonollo, 2002).The design process is all the work done in the pursuit of a solution. Our approach, at this level, emphasises learning a general design process over traditional ID skills. Essentially, it amounts to solving design problems in iterative processes described by Petroski (1992), that consist of failure after failure in diminishing degrees until success is attained. There is no secret sure-fire formula, examining 'design ability,' Cross (1995) summarised what designers do based on the words of practitioners. “Designers

- produce novel, unexpected solutions
- tolerate uncertainty, working with incomplete information
- apply imagination and constructive forethought to practical problems
- use drawing and other modeling media as a means of problem solving”

Design students also have pre-conceived notions about the abilities needed to fit into their chosen discipline, that more specific than a type of general skill in designing. ID students soon become aware of the work of other professionals in their field. Instructors, therefore, feel duty-bound to help students develop traditional skills, in this case, those of concept design and communication. Congruent with the findings of Lewis and Bonollo and Yang et al, our students regularly return from their work experience or their new design jobs, admitting that they need to improve their “sketching”, or “rendering”, or knowledge of this or that “CAD software program”. Many ID departments will likely address some of the competencies identified by Yang et al through discrete requisite courses, in this respect our programme is not unusual. We offer: Computer Aided Technical Drawing, Computer Aided Industrial Design

courses and Advanced Design Presentation that correspond to '2D and 3D graphic software requirements'; the Materials and Production Technologies I and II and Design Engineering courses that deal with 'knowledge of moulding tool or plastics injection'; the History and Theory of Industrial Design and Contemporary Issues in Industrial Design courses that hope to instil awareness of 'popular messages and trends', defined by Yang et al.

Consequently our design studio course emphasises three distinct areas of competence in designing that are the focus of our curriculum and the foundation of it's diverse parts, namely, the brief, activities of the studio, and assessment:

- Design process: The intellectual act of solving a design problem—however it is formulated— entailing enquiry, reflection, iteration, creativity, doing.
- Design concept: The imagination and sensibility to conceive of appropriate design ideas that are the particular contribution of the industrial designer.
- Presentation: That particular skill mentioned in the account of Harley Earl and the GM designers to communicate evocatively.

THICK CURRICULUM

Learning is the process whereby the student undergoes change, previous understandings are challenged and new ones have to be accommodated. Learners need to, know how to learn, access information, apply what is learned, and address complex real-world problems. However, the novice first approaches the discipline with preconceptions about the substance and nature of the discipline. In teaching a freshman design class, Newstetter and McCracken (2001) observed that students bring a naïve theory of design to the studio affecting how they imagine the designer's role and the process by which the designer arrives at solutions. To address student preconceptions, we began the semester with two quick warm-up design exercises in the first week, for students and instructors to become acquainted, and to introduce the concepts of the course and explain it's aims. Instructors reviewed the work at the end of each exercise. We wanted to contrast our approach to their experience in first-year art and design studio, provide early, quick successes for students to enjoy. At the outset, we were at pains to demonstrate that,

- instructors are concerned with process rather than results, design decisions made at this stage of their career are low-stakes choices;
- the process is not mysterious, solving design problems follows a self-evident trajectory;
- there are a diversity of solutions and forms of expression, all have their own merit.

Students then began the first of two main design projects, to design a plastic moulded tool box for a purpose of their choice. They worked exclusively on this project for 5 weeks, when the second project was initiated, to design a utility knife with standard replaceable blades for an application of their choice. We alternated our attention from project to project about every two weeks for the rest of the semester. We held two projects to provide variety (some students may not like a particular brief) while availing enough time for novice designers to thoroughly explore the design problems. The projects are calculated to be increasingly challenging through both semesters of the second year. The design studios often began with morning meetings interspersed with discussions that were set off with questions like: What is

a designer? What is a professional? Here, the aim was to orientate and motivate students, to remind them of their purpose and dispel misconceptions about education, design practice and practitioners. Studio is seen as the centre of design education and so it's an appropriate place to reflect on the education process.

Wk	Date	Project A: Plastic toolbox	Project B: Utility knife
1	24.09	*Quick design brief* Ecological niche for alien creature	
	26.09	*Quick design brief* Disposable card tray for Firuz Catering	
2	01.10	*Discussion* What is a designer *Introduction to brief* Plastic toolbox General discussion session, paperwork... Brainstorming session	
	03.10	Submission Paperwork	
3	08.10	*Discussion* What is a professional? Check Design log, folder etc.	
	10.10	*Discussion* Design process Morphology session "The pitch" session	
4	15.10	50 Sketches "If I were you..." session Sketch charades session	
	17.10	*Rehersal* Green light session	
5	22.10	*Presentation* Green light session First model	
	24.10	Morphology discussion, session	*Introduction to brief* Craft knife General discussion session

Wk	Date	Project A: Plastic toolbox	Project B: Utility knife
6	29.10	*Holiday*	
	31.10		*Presentation* Market research Mind map session
7	05.11		Submit research report Design log and paperwork Drawing game (sketch charades) session
	07.11		"If I were you..." session 50 Sketches *Rehersal* Green light session
8	12.11		*Presentation* Green light session 3 concepts and 3 models 1:1 Morphology brainstorming session?
	14.11		Drawing hands and rendering session
9	19.11	Submit user and context research	

Wk	Date	Project A: Plastic toolbox	Project B: Utility knife
	21.11	*Presentation* Product concept board Sketch design concept Accurate model, scale 1:1, in card 100 sketches	
10	26.11		
	28.11	*Discussion* Analysis of plastic containers or toolboxes	

Figure 1. Part of the ID studio timetable.

REFLECTION

The choices awaiting the designer are considerable, insurmountable mountains of information loom in their search for solutions. The courses of action appear to be infinite. “Where do I begin?”, is the deceptively profound question that a novice designer is compelled to ask. Schön (1987) put the “paradox” as such: “a student cannot at first understand what he needs to learn, can only learn it by educating himself, and can educate himself only be beginning to do what he does not yet understand.” Students need to put their trust in the process because learning to design is risky with no guarantee of success. Our studio is slow, deliberate paced, so that students may 'walk' through the design process. In undertaking the design project, students however, do produce a significant amount of work for this level. Students need adequate time and opportunity to engage in a “reflective conversation” with the situations in which they find themselves, as Schön described (1991). The design practitioner's artistry involved in “situations of uniqueness and uncertainty”, he called “reflection-in-action”. This is process (briefly) whereby designers ponder their actions, and the situation talks back to them, leading them to “reappreciate, reinvent and redraw.” The idea of a process—a patient journey toward it's destination, is implicit in our studio. One way in which we aid students to reflect is occasionally remind them, as a group in class, of their progress, in order to encourage a kind of situation awareness, to reflect on the reflecting, like Schön's “reflection-on-action”. For that purpose, we find John Chris Jones' (1992) three-stage description of the design process is a useful concept to help students understand their general progress in a project. According to Jones, “divergence,” the first stage, “refers to the act of extending the boundary of a design situation so as to have a large enough, and fruitful enough, search space in which to seek a solution.” “Transformation”... “is the stage of pattern-making, fun, high-level creativity, flashes of insight, changes of set, inspired guesswork; everything that makes designing a delight.” “Convergence”... “is the stage after the problem has been defined, the variables have been identified and the objectives have been agreed... reducing... progressively until only one of many possible alternative designs is left as the final solution to be launched into the world.” Detailed conceptions of the design process may be too prescriptive. In the above cited paper, Lewis and Bonollo adapted a model of the ID process with five stages, beginning with “task clarification'; then “ concept generation”; “evaluation and refinement”; “detailed design of preferred concept”; and finally, “communication of results.” In practice, such a plan may provide structure to problem solving, and be useful for managing design projects; for teaching, such a model may be more applicable to advanced students doing live projects, as

was the case in the study.

EDUCATIONAL SCAFFOLDING

In the divergent phase, the brief is discussed. Students are guided on the type of research required, they are introduced to market (desk) research, observational (field) research as basic methodologies. In the following semester, more rigourous research approaches will be expected, and students will be pointed to reliable resources for research. The typical design process begins with students considering the product concept and evolves in time to giving full consideration to design concept. It's apparently easier for students to imagine contexts of use for a toolbox—say 'a toolbox for a fisherman' (product concept)—than to shape the form and details of a fisherman's toolbox (design concept). In our minds, the former skill relates to Buchanan's 'wide perspective', and the later skill is the traditional contribution of ID.

Our 'thick' curriculum has explanations for, and guidelines on practically every stage of the design process. Handouts describe the type of paperwork encountered in a design project and keeping track thereof; the role of drawing and types of drawings, brief introductions to different design methods etc. Design methods are introduced and tried throughout the design process, the most common are (references included for information):

1. Mind mapping—delineate the project, at it's outset, in groups (Margulies and Maal, 2002).
2. The post-up—as mind mapping, using post-it notes (Straker, 1997).
3. Brainstorming—a versatile method used especially early in the design process (Lumsdaine and Lumsdaine, 1995).
4. Morphology—break down the design problem into discrete elements and brainstorm for solutions (Cross, 2000).
5. Brain sketching—sketch version of brainstorming (VanGundy, 1988).
6. Sketch charades—work in pairs to solve detail design problems (developed by the authors).
7. Harvey cards—a checklist used to expand the solution area (Lumsdaine and Lumsdaine, 1995).
8. Scenarios—describing a user, product and context of use (Suri and Marsh, 2000).

In the following semester additional methods are introduced, for example, as heuristics for specific classes of design problems such as hand tools (Cacha, 1999), analysis techniques for evaluating design concepts (Morgan D. Jones, 1998), principles and techniques for designing computer user interfaces (Cooper, 1999) and techniques for prototyping interfaces (Snyder, 2003) etc.

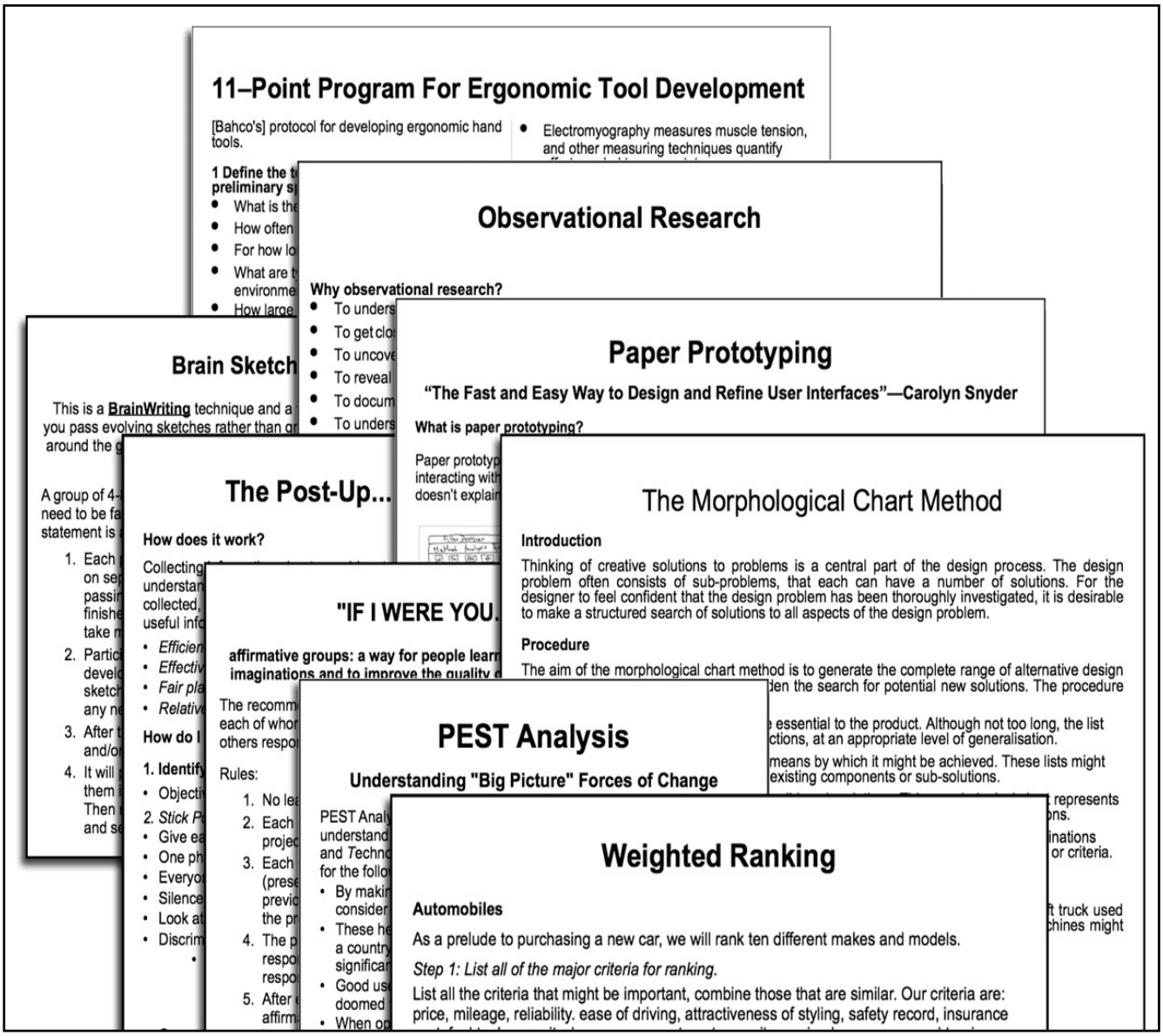

Figure 2. Design methods handouts.

Specific studio sessions are held according to the phase of the design process. During the transformation and divergent phases “If I were you...” affinity groups allow the students to discuss and reflect on each other's work, avoiding offensive and defensive behaviour. “The pitch” session was held for students to describe their concepts in a rapid-fire way, imitating the famous Hollywood pitch. “The green light” session features a miniature traffic light where instructors give the go-ahead to the students' best product concepts with unambiguous responses, either green for 'go'; orange for 'reservations'; or red for 'no.' In the utility knife design project we analysed utility knives in a 'product disassembly' session.' We also held a 'hand drawing and rendering session.' ID students commonly have pre-conceived notions that they should be talented at drawing/rendering. Those abilities do not stem from birth, so a drawing/rendering session at the right time, reminds students to address their shortcomings

as they come up, an approach conducive to professional life-long learning.

Figure 3. Green light session; Hakan Gencol and Aysun Aytaç agreeing with students which of their three product concepts gets the 'green light'.

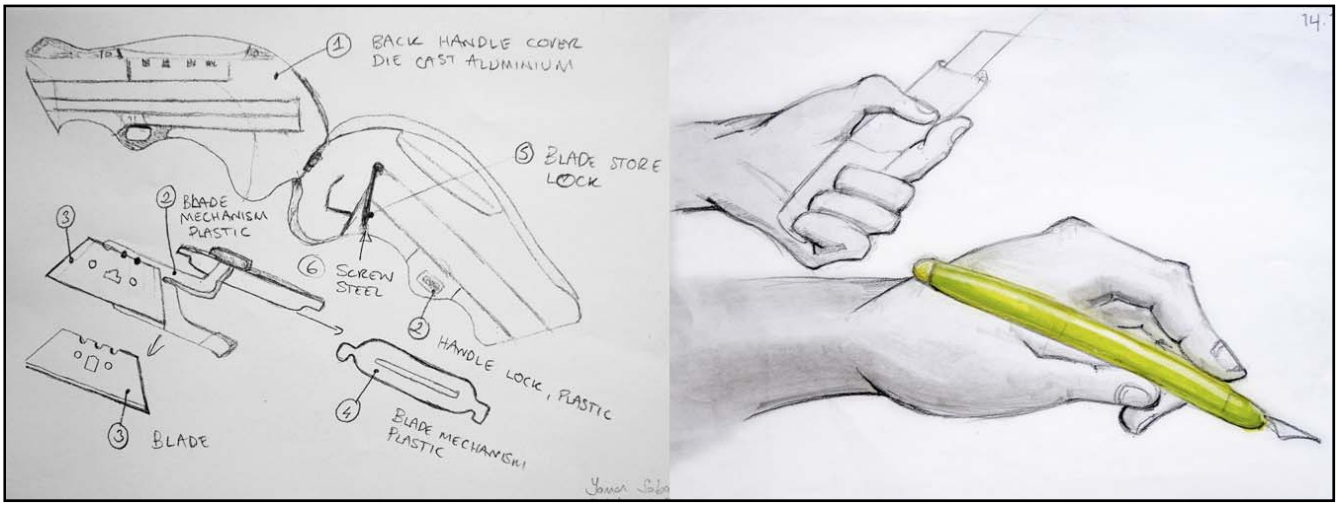

Figure 4. Examples of student sketches during the 'product disassembly session' and the 'hand drawing and rendering session.'

Our ID studio is 'thick' with materials, tasks and activities that are intentionally sequenced so as to optimise learning in a process that is known as educational 'scaffolding.' Instructors bring their respective experience and knowledge to bear in a systematic way so that “students are given support until they can apply new skills and strategies independently” and are particularly useful for teaching “higher level cognitive strategies” such as “comprehension and

interpretation of text, scientific processes, and mathematical problem solving” (Rosenshine and Meister, 1992). The design methods and heuristics we use are like “concrete prompts” or “procedural facilitators” described in their paper, that are a part of scaffolding. Another scaffolding technique is “thinking aloud”; design tutors can do this when working together with a student on a problem, for example when sketching, to give students insight into their “expert thinking” or reflection-in-action, which would otherwise be obscured.

A significant feature of our thick design studio is the importance we place on drawing and model making, as intellectual pursuits central to successful designing (Pipes, 2007) and (Nagashima and Sano, 1994). Indeed, according to Rodgers et al (2000) “visual representations are omnipresent throughout the NPD process” and “sketching is one of the most important activities in the design and development of new products”. We expect students to make use of these fundamental ID tools, by making a number of 2D sketches and 3D models (physical and/or CAD.) Although we are doubtlessly not unique here, our approach may be novel. Sketching and model making are seen as essential design tools that we expect students to utilise. Many students have never before sketched for this purpose. We described it as an arranged marriage: “Designer, meet sketching, your new partner, enjoy her/him and, who knows, one day you may fall in love.” At a certain stage we will demand 50 sketches (stipulated as one idea sketch per page) for the following week, after all, ideas are cheap to produce. That demand is normally repeated so that by then end of each project each student will have an absolute minimum of 100 sketches, and most likely more as a record of their 2D design process. Most students produced four models of the toolbox and six of the utility knife. Sketching and model making are aids to reflection-in-action, records of ideas and means of communication. Both drawing and model making should more-or-less proceed from general, rough versions at the early stages of the design process, converging with increasingly accurate iterations into the final design concept in millimetre precise drawings and models at the end. We believe that an exemplary design process, at this level, should show evidence of 'breadth'—meaning “a wide search for solutions” where a “range of alternatives explored throughout”; followed by “an incremental refinement of the chosen solution” where “elements of the final design concept are developed thoroughly and in detail”—which we call 'depth.'

Experience has taught us not to underestimate the amount of knowledge entailed in merely adapting an general idea for a plastic toolbox into a design of a toolbox that can be feasibly moulded in plastic. Once the basic product concept has been defined students were expected to gradually develop and adapt the design concept so that it could be conceivably moulded. That entails, at least, some idea of plastic family types, a grasp of different moulding processes, principles of moulding such as draft angles and undercuts, plastic moulding design details such as hinges, mechanisms and ribs, assembly techniques using snap fits, bosses and screws, and finally, finishes, colours and textures. This vast mountain of declarative and procedural knowledge that novice designers must rapidly scale at this stage of their learning is an impediment to the goal of a hands-off tutoring style. The results indicated that the majority of students had not attained a satisfactory understanding of plastic moulding. To rectify this would, in future, call for an effective co-ordination between design studio and materials and production courses.

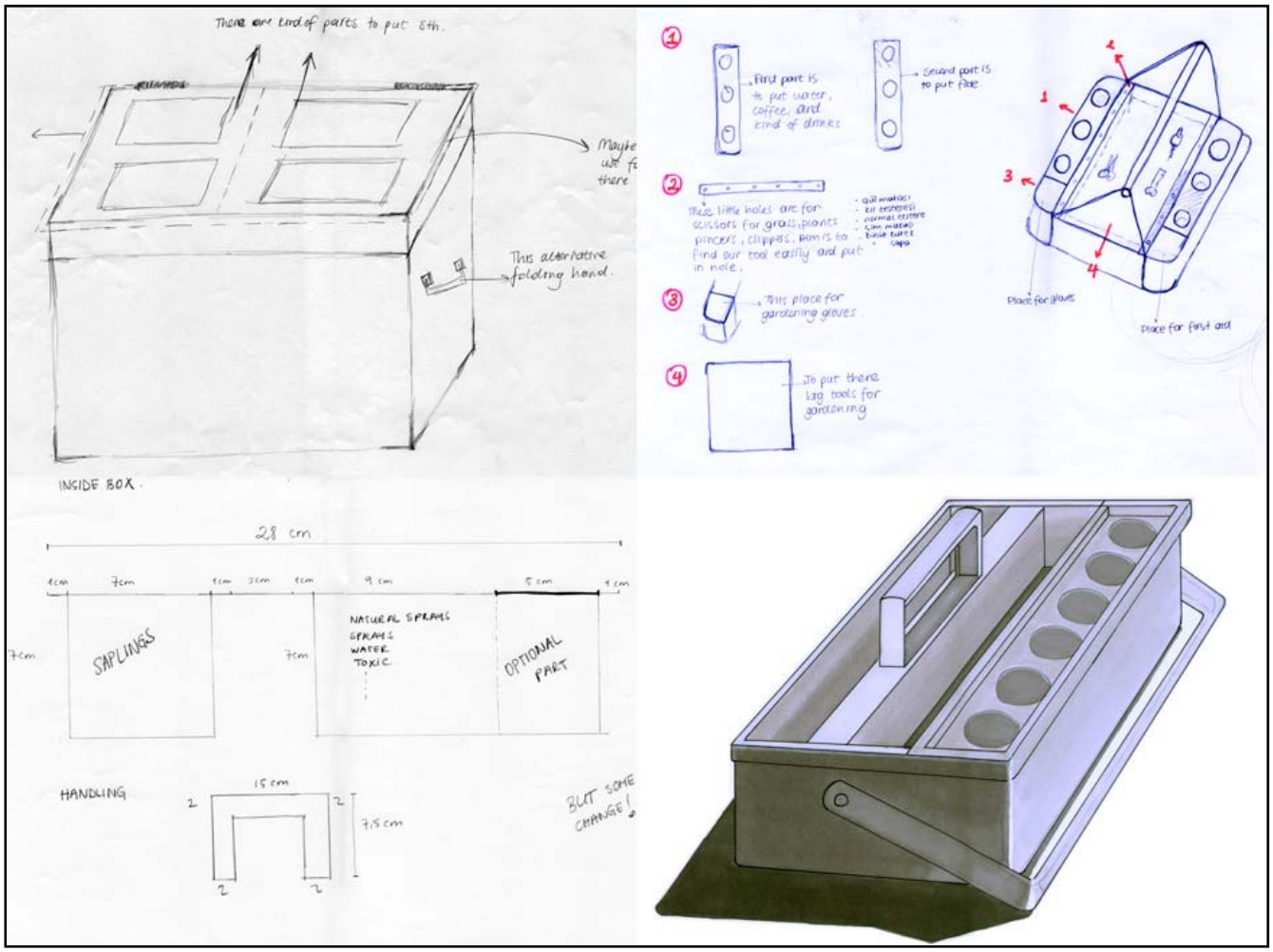

Figure 5. Example of 2D process that shows the emergence of a definitive design concept from an early sketch (top left) to the final rendering in perspective for a gardener's toolbox by Efecan Çakmakci.

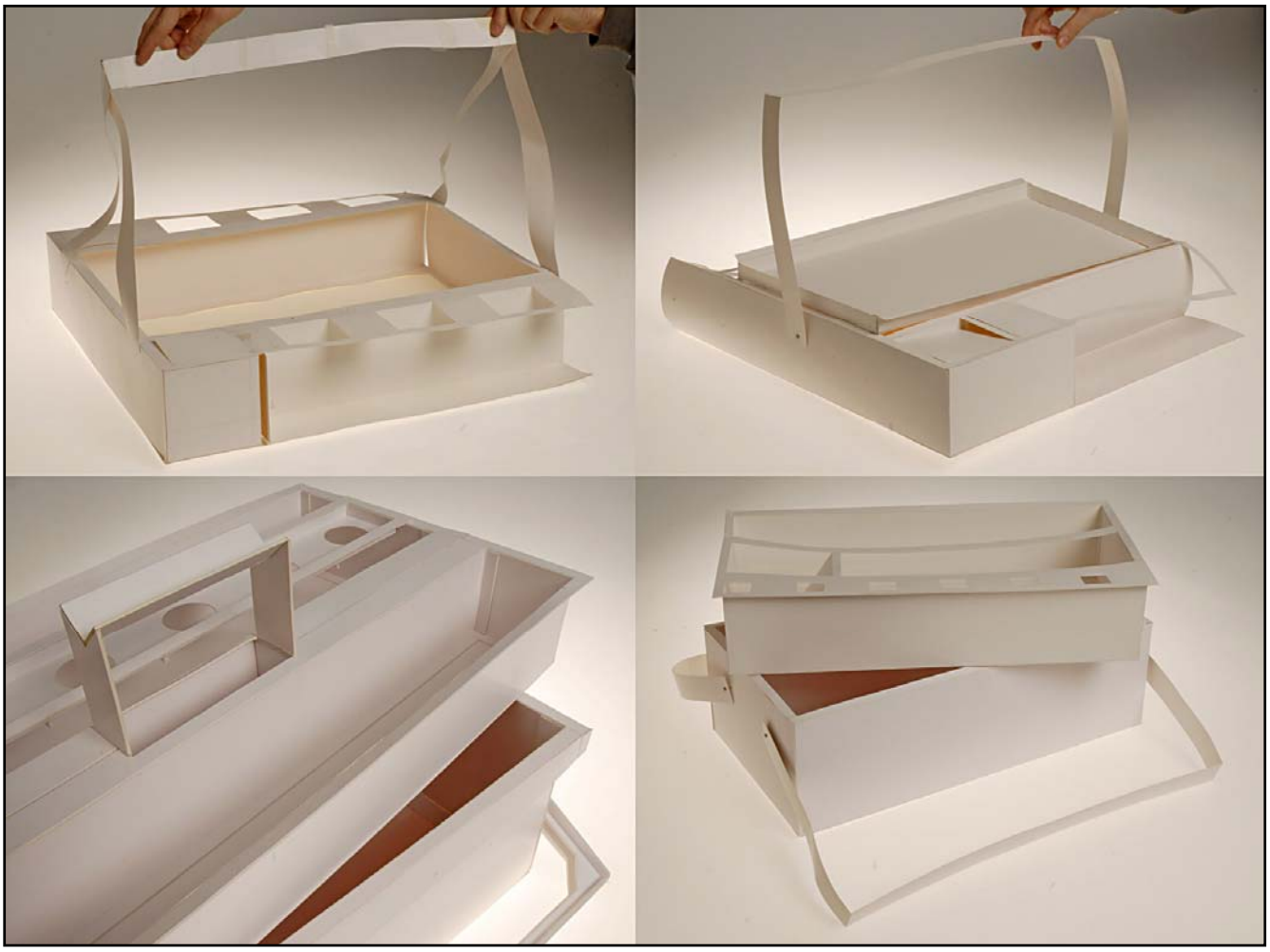

Figure 6. 3D process of the same gardener's toolbox by Efecan Çakmakci, with early iterations (top) and the final model (bottom left) that is a feasible proposal for a mass produced plastic injection moulded product.

The successful running of a design studio depends on the motivation of students and staff. In our experience, an inevitable part of maintaining morale and motivation consists of what we term shepherding and coaxing. In shepherding, we instruct, we remind, we guide, we clarify, we repeat incessantly and we provide information in a timely fashion and are specific about requirements. In coaxing – we encourage, we coerce, we even threaten! A sample email, sent to the student group that semester, begins with an implied threat and expectation of excellence: "You have had a long time to think of excellent toolbox product concepts;" and continues by repeating and describing the specific requirements for the “green light session.”

We tend to address the student group, either in class or by using a email, when providing instructions. Dealing with 40 or so students in a studio with a hands-off tutoring style has it's advantages. It is needless to analyse every decision made by each student to the nth degree. Students designers should be give space to make discoveries; and to allow for oversights and neglect, with opportunity to rectify mistakes. Even though they are novices, excessive

monitoring be a mistake, “indoctrination” may be the result "if the student is forced to acquiesce or comply with the expectations of the studio instructor rather than having the place to play spontaneously with personally invented or discovered design solutions" (Ochsner, 2000).

-------- Original Message -------- Subject: [id_ieu] ID201 Product Design studio - Toolbox green light session Date: Fri, 19 Oct 2007 16:06:16 +0300 From: Alex Velasco <alex.velasco@ieu.edu.tr> To: id_ieu@yahoogroups.com
Hi all, You have had a long time to think of excellent toolbox product concepts. On Monday we will have the 'green light' session. Students present product concepts to instructors to get, either the green light, orange, or red. You will get the green light if we agree that your product concept is worthwhile. Bring the following on Monday: a. Your best product concept. At least one concept (maximum 3.) b. 1 concept on 1 A3, or more, pages. c. Draw clearly and use text to describe your product concept. d. Describe your product in terms of... * name, 'Miss Tweetie' etc. * title, 'toolbox for fisherman with special anti-theft features' e. When you describe your product concepts, think in terms of... * innovation, what is new about your product? * feasibility, how will your product be especially profitable? * aesthetic values, what will be significant about it's appearance? * contextual relevance, why is it a good idea? f. Model in card. Scale 1:1. Quick model, show basic function and overall size, not details etc. Make 1 model of each concept you show. We will have to work fast to see all 44 students. Remember to bring your design log and all paper work including sketches to design studio, every time. Regards, Alex

Figure 7. 'Shepherding' and 'coaxing' evident in this sample email.

STUDENT WORK AND ASSESSMENT

Undergraduate ID studio assessment is conventionally limited to a subjective evaluation of student design projects. The skills and characteristics are evaluated and totalled. According to

Potterton and Parsons (1994) all summative assessment profiles have two basic purposes: 1. To acknowledged achievement and, 2. Form the basis for a report for all interested parties. “Fundamental assessment principles” as they apply to schooling are summarised by McMillan (2000): Assessment is “essentially a process of professional judgment”; it is based on “principles of measurement evidence and evaluation”, where “evidence” entails differentiating by giving scores and “evaluation” entails understanding results using descriptive statistical procedures etc.; it is “influenced by a series of tensions” such as that between learning and measuring; it “contains error”, an issue known as “reliability”; if “enhances instruction”; it is “valid”, that has to do with the evidence being assessed, its relevance, etc.; it is “fair and ethical”; it uses “multiple methods” to get a more complete picture of learning; it is “efficient and feasible”; and it “appropriately incorporates technology”. Gipps (1994) offers a 'broader definition' of a form of educational assessment 'used in support of learning' that summarises recent educational thinking at school level, that recognises that 'domains and constructs are multi-dimensional and complex;' that assessment 'is not an exact science;' that ' clear standards' should be set for performance; that 'tasks need to be anchored in important and relevant subject matter.' Assessment should 'move away from the notion of a score, a single statistic, and look at other forms of describing achievement including “thick” description of achievement and profiles of performance.' Assessing and providing the emerging ID practitioner with formative feedback about their reflexive 'capacity to develop critical awareness of the assumptions that underlie practices' (Edwards 2002) would call for extended conversations between the student and their tutor/mentor combined with tools, such as discourse analysis, and is explored in a paper by Velasco (2008.) Jackson (1994) warned that “several assumptions” appeared to support art and design assessment practices:

- that students' achievements of course objectives can be judged adequately from looking at the physical artwork products;
- that students develop progressively towards their best work, and that their 'exit velocity' is the best and fairest measure of their ability;
- that students are novice designers, who, on graduation become qualified, if somewhat junior, experts;
- that the judgement of student readiness to join the fraternity of designers rests most properly in the hands of proven experts—that is, designers working in education;
- that the concept of 'final assessment' is a useful and valid one.

Assessment practices in design education are traditionally based on the principle that “learners must demonstrate that they have mastered specific skills and competencies by doing something or producing something”; and that “the tasks should demand the procedural, conditional and declarative knowledge required for mastery of the specific domain” (Maclellan, 2004), this is called 'validity'. We don't buck the trend. However, considering Jackson's assumptions, in grading we do not only consider final works, but also the process and, to some degree, student participation throughout the semester. Our assumption parallels Schön's reflection-in-action; learning to design is predicated on an engagement in and manipulation of the elements of the design problem. Evidence of that learning will be found by examining the physical materials and results of the design process.

At the end of each project the outcomes are spelt out. For the design process, the approximate number of sketches in the 2D process, approximate number of models, records

of use of design methods, records of desk and field research. For design concept, a written design project description is required to justify the final product. For presentation, the specifics of 2D renderings, 3D models and technical drawings are detailed. Other attributes of the current student/learner and emerging professional are assessed through a specific grade for 'participation,' worth 10% of semester grade, where points are awarded throughout the semester for timely and successful accomplishment of tasks. This is another shepherding technique used to encourage individuals to remain up-to-date in such a large group of students. The assessment criteria are published with the brief at the outset of design project. Students are remind throughout project of the criteria, which is to say they are reminded of pedagogical aims of the studio, with statements like “all the work you do throughout the project is valuable, don't forget, your design process is worth 50% of the grade.”

Toolbox outcomes	Utility knife outcomes
2D process [A3 sketch folder] over 100 sketches 3 models	2D process [A4 sketch folder] over 100 sketches 6 models
Design log [A4 ring binder file] Project CD with Design concept description document, Creator description document, AutoCAD technical drawing original Brief documents Timetables Notes Design methods: Project mind map, If I were you, Morphology, Brainstorming methods Desk Research: Plastic moulding information, Other desk research Field Research: Observation user and context, Tools and dimensions 2D presentation	Design log [A4 ring binder file] Project CD with Design concept description document, Creator description document, CAD model originals, CAD rendering originals Brief documents Timetables Notes Design methods: Project mind map, If I were you, Morphology, Harvey cards, Brainstorming methods Desk Research: Anthropometric report, Market research, Other desk research Field research: Observation user and context 2D presentation
2D perspective manual renderings A3 (x2) Product concept board A3 Technical drawing Technical drawing, scale 1:1 or 1:2, GA 3D Model Final card mock-up, scale 1:1	Orthographic CAD renderings scale 1:1 (x3) A4 Perspective CAD rendering (x1 or 2) A4 Exploded view CAD rendering A4 3D CAD Model Final balsa model, scale 1:1 in protective box

Figure 8. Outcomes for design work that will be submitted for assessment are spelt out.

Design studio instructors can fall into the trap of evaluating only the student's design concept, while bemoaning a paucity of design process. Our assessment criteria attempt to closely reflect the objectives of the course and be a fair reflection of student achievement. Students are required to submit all the work done “in the pursuit of resolving the design project.” The crit or jury is closed to students, the work, alone, should do the talking. We give the students a

'soft landing' at the project's end, by eliminating the stress and rigours of performing at a crit, an experience that is not essential at this level.

Thanks to shepherding, students who participate with reasonable effort in design studio, can rightly expect to pass, by merely assembling all their work and submitting it at the end of the semester. Final evaluation is unlikely to bring surprises in this respect. As our assessment is designed to consider a number of elements, a student is unlike to suffer disproportionately if one or a few elements are missing. Nevertheless, it is a characteristic of ID projects that the intentions of the designer are only properly understood if the information provided in the 'presentation' is sufficiently complete, so there is something of a knock-on effect when presentation elements are missing. Assessment criteria are described as follows:

Design process	Work done by the designer/s in the pursuit of resolving the design project. It embodies the idea of an iterative process that entails a wide search for solutions and then an incremental refinement of the chosen solution. It is characteristic of this idea of the 'design process' that, at the outset, the designer has no clear idea of the final outcome.
2D Exploration and Refinement	Drawing as a tool for thorough exploration and refinement of the design concept, throughout the design process. 'Exploration' ~ a wide range of alternatives explored throughout. 'Refinement' ~ elements of the final design concept developed thoroughly and in detail.
3D & CAD Exploration and Refinement	3D and CAD model making as a tools for thorough exploration and refinement of the design concept.
Research	All research undertaken. Including written notes, articles, interviews, photography, video etc.
Design Project Log	Conscientious and well organised record of the design process.

2D exploration and refinement: The 2D process is for experiment and failure, in an iterative, incremental development of ideas. Drawing is a tool for creative thinking and a record thereof. We expect to see a wide variety of design ideas at the early 2D process, represented by general, rough sketches; evolving to a thorough refinement of the chosen design concept, shown with increasingly accurate sketches and orthographic drawings.

3D model making: Model making helps the designer in similar ways to drawing. We similarly, expect models to evolve from the approximate to the precise.

Design doesn't happen in a vacuum. We introduce our novice designers to sources of information through market research tasks. In the next semester they will expand the search to include market intelligence reports, consumer reports and scientific papers, from disciplines such as ergonomics, that apply to the product type. Research is not expected to be wide ranging, because of the difficulty for novice designers to absorb new information and apply the learning effectively under the time constraints.

The design project log is an A4 folder that is a record of the industrial design process of a single project. It should be organised with the needed information that applies to the design project, such as: Brief documents, notes, correspondence, design methods guides, back up

CDs of computer data, research reports, catalogues or brochures (where practical,) prints of technical drawings etc.

Design Concept	The solution of the design project that is being proposed by the designer/s. The 'design concept' should be evaluated wholly by information provided in the 'presentation' elements. E.g. Whether a design concept can be feasibly manufactured should be evident in it's technical drawings etc.
Innovation	In terms of function, arrangement of components, application of technology, design details etc.
Feasibility	In terms of manufacturability, marketability etc.
Aesthetic Values	Appropriateness of appearance in terms of intended market, competitors etc.
Contextual Values	The potential of the design concept in the market, considering the social, cultural, political and economic context in which the final product will operate. “Does it have the x-factor?”

Design concept is modestly weighted, it entails values, philosophies and questions of taste that are personal to the designer. For Borgmann (1995,) designers are professionals entrusted by society, responsible for the excellence of material objects. It follows that it would take time to acquire insight into the subtleties of the material culture, “unique in it's scale and sophistication,” and even more time for the designer to develop a personal and professional response to these “intricate and consequential matters.” We consider these naïve, first steps in designing and that the submitted project comes at the end of a challenging multi-faceted learning period, there is no need for an overbearing assessment procedure. While design concept is a worthy area of discussion, it is questionable whether interpretations of the zeitgeist of material culture are appropriate subjects for thorough deliberation, at this level.

Presentation	Information—in the form of specifications, renderings, models and technical drawings, that is the end product of the ID process—that is prepared to communicate the design concept to other members of the product development team.
2D Presentation	Manual or CAD renderings for presentation. Adequately communicate design concept elements, especially: Innovation, aesthetic values and contextual relevance.
3D / CAD Model	Adequately communicate design concept elements, especially: innovation, feasibility, aesthetic values and contextual relevance.
Technical Drawings	Adequately communicate design concept elements, especially: innovation and feasibility.

Instructors are often confronted with a great diversity of ability in a student group. Those students who begin at a low level, need time to develop proficiency. We aid this process by simplifying the submission requirements (not the level of skill required) and communicating them clearly.

Figure 9. Feasible plastic design detailing required in injection moulding in this exemplary final model of an artist's toolbox by Ece Eru.

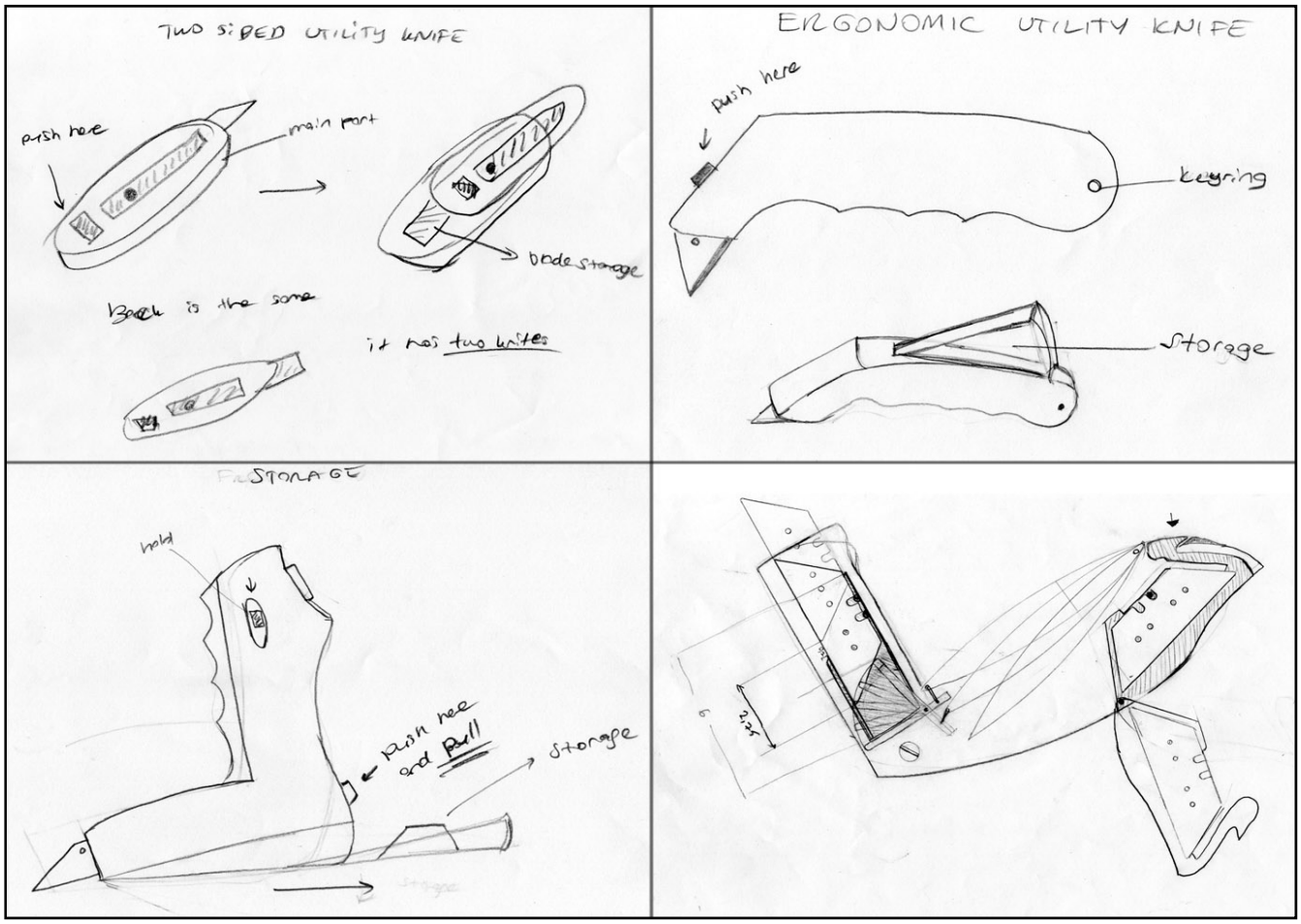

Figure 10. 2D process of a utility knife by Ekin Zileli. The diverse exploration drawings are an example of a broad process (top) and later drawings that develop the chosen design concept (bottom) are what we mean by depth.

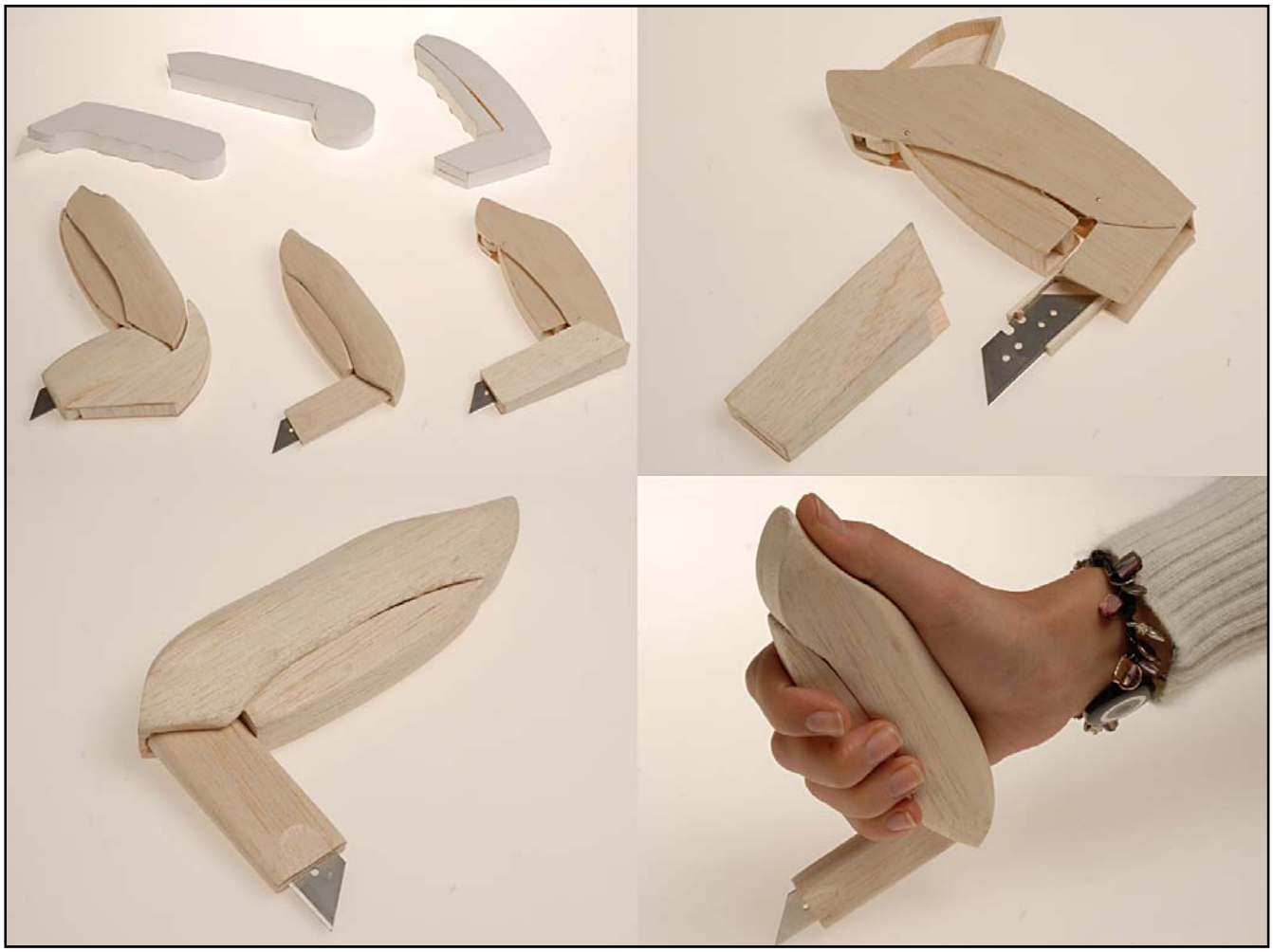

Figure 11. 3D process of a utility knife by Ekin Zileli also demonstrates breadth (top right) and depth with a working prototype in balsa wood (top right). The 3D process ended with a final appearance model in balsa wood (bottom).

In this way, assessment plays its role as an acknowledgement and a report of learning, while simultaneously providing the student with an additional opportunity for reflection-on-action. Our purely summative assessment method, we believe, has the following advantages for this level of student:

1. Rewards the total effort put into a design project.
2. The design project is broken down into discrete, recognisable parts.
3. Criteria are closely tied to the design studio pedagogy.
4. The range of criteria, reinforce the principle that a design project is multi-faceted, it cannot be fairly adjudged by considering only one aspect.
5. The student may ponder the feedback, of each instructor, on every aspect of their project.

6. Recognises achievement in all aspects of the project, most students can take heart that they did well somewhere.
7. Mindful of the approximate nature of grading, by using a limited scale of 0-5, only whole numbers, and the instruction to give the student the benefit of the doubt.
8. Summative assessment is exactly that—a summation.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1		ID201 Product Design Studio I						AA	Aysun Aytaç				DI	Derya Irkdas					
2		Utility Knife						HG	Hakan Gencol				AV	Alex Velasco					
3		"18.01.2008"																	
4			**Mark total**		**20**			**20**					**5**			**5**			**5**
5					2D Exploration and Refinement			3D Exploration and Refinement					Research			Design Project Log			Innovation
6		**Name**	**Surname**		AA	AV		AA	HG	DI	AV		DI	AV		DI	AV		AA
7	1	[redacted]			5	4	4.5	5	5	5	5	5.0	3	3	3.0	3	3	3.0	5
8	2	[redacted]			3	3	3.0	5	5	5	5	5.0	3	3	3.0	4	4	4.0	5
9	3	[redacted]			5	5	5.0	5	4	4	5	4.5	4	4	4.0	3	3	3.0	5
10	4	[redacted]			5	5	5.0	5	5	5	4	4.8	5	5	5.0	5	5	5.0	5
11	5	[redacted]			5	4	4.5	5	4	4	5	4.5	4	5	4.5	5	5	5.0	5
12	6	[redacted]			5	5	5.0	5	5	5	5	5.0	5	5	5.0	5	5	5.0	5
13	7	[redacted]			4	4	4.0	5	3	3	4	3.8	3	3	3.0	3	2	2.5	3
16	10	[redacted]			5	4	4.5	5	5	5	5	5.0	5	5	5.0	4	4	4.0	5
17	11	[redacted]			5	4	4.5	5	4	4	5	4.5	3	3	3.0	3	3	3.0	5
18	12	[redacted]			5	4	4.5	5	5	5	5	5.0	3	3	3.0	3	3	3.0	5
19	13	[redacted]			4	4	4.0	5	4	4	4	4.3	4	4	4.0	3	4	3.5	4

Figure 12. Portion of the spreadsheet table used in final assessment. The highlighted yellow band shows how a student (rows 11) may reflect on the feedback given by each instructor (columns E, F, H, I, J etc.) for each criterion of the assessment.

DISCUSSION

Students and instructors are in for a challenging time when they meet in the design studio. Students, of varying motivation, fully expect their short time at university to catapult them to professional competence. The demand for design instruction is not abating, at least in Turkey, which means that increasing numbers of graduates can look forward to a trying future of

uncertainty in the face of competition and broader structural economic, political and social changes. Our teaching involves strategies to equip our graduates with the skills and knowledge appropriate for practising professionals. We have distilled developments in design and educational theory appropriate to novices, which focussed on identifying key competencies of the ID professional; populating the studio experience with methods of the discipline and variety of didactic strategies; and providing an environment and opportunity for the individual professional practitioner to emerge. Our studio curriculum, itself, is constantly changing. New elements and ideas are added incrementally. This paper describes that work in progress. Each year is an experiment, and the empirical data, in the form of student work, scores and our hunches suggests that we are enjoying some success. Further study, specifically longitudinal evaluations of the transformation of individuals exposed to these types of programme to qualify and measure their effectiveness, is essential, and should in fact be routine. Industrial design education sorely needs a free exchange of it's best practices, in order to remain relevant to the constantly changing professional context.

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